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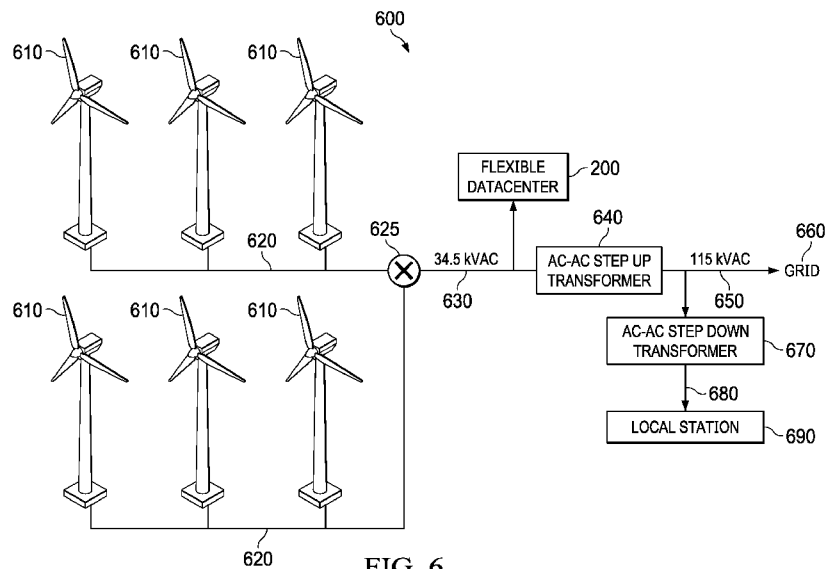


FIG. 6

(57) Abstract: A flexible datacenter includes a mobile container, a behind-the-meter power input system, a power distribution system, a datacenter control system, a plurality of computing systems, and a climate control system. The datacenter control system modulates power delivery to the plurality of computing systems based on unutilized behind-the-meter power availability or an operational directive. A method of dynamic power delivery to a flexible datacenter using unutilized behind-the-meter power includes monitoring unutilized behind-the-meter power availability, determining when a datacenter ramp-up condition is met, enabling behind-the-meter power delivery to one or more computing systems when the datacenter ramp-up condition is met, and directing the one or more computing systems to perform predetermined computational operations.

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METHOD AND SYSTEM FOR DYNAMIC POWER DELIVERY TO
A FLEXIBLE DATACENTER USING UNUTILIZED ENERGY SOURCES

BACKGROUND OF THE INVENTION

[0001] Blockchain technology was originally conceived of as an open and distributed system for securely conducting transactions with cryptographic currency. However, the foundational principle of blockchain technology is the ability to securely transact information of any type or kind between anonymous parties without intermediaries or a centralized trust authority. As such, blockchain technology finds application outside the realm of cryptocurrency and is widely considered one of the more robust and secure means of transacting information in the computer sciences.

[0002] In typical blockchain implementations, each participating party creates a digital identity, or wallet, which includes a pair of cryptographic keys used to transact information securely and anonymously with the blockchain. The blockchain may be thought of as a constantly growing database of all prior transaction information that is securely and coherently replicated across all nodes of a peer-to-peer blockchain network. The blockchain includes a sequence of blocks, where each block includes a bundle of transactions and other data including a hash of the prior block in the chain. As such, each block in the blockchain is mathematically related to the prior block, protecting the integrity of the blockchain from the most recently added block to the genesis block in the chain. Because anyone may participate in the curation of the blockchain, once a block is added, it becomes a permanent and immutable part of the blockchain. Thus, the blockchain stores transactions in a manner that prevents the transactions from being altered or otherwise corrupted, unless all subsequent blocks in the blockchain are also altered. The immutability of the blockchain makes the malicious alteration of a block exceptionally difficult, if not impossible, and at the very least makes it easy to detect and deter any such attempt before being accepted and replicated across the blockchain network.

[0003] Each transacting party of the blockchain uses a pair of cryptographic keys to anonymously transact information. The private key is a random number maintained in secrecy by the party holder that is used to derive a public key and sign information. The private key and the public key are mathematically related such that anyone holding the public key may verify that information signed with the private key originated from the holder of the private key. When an initiating party wishes to

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transact information, the information is signed with the initiating party's private key and broadcast to the blockchain network. A blockchain miner uses the initiating party's public key to verify that the initiating party initiated, or signed, the transaction. Once the initiating party's signature is validated, the transaction is validated, added to the next block in the blockchain, and replicated across all nodes.

[0004] The computational overhead of the blockchain is largely due to hashing functions used by blockchain miners to discover new blocks. While computationally intensive, the work performed by miners is critically important to the functionality of the blockchain. When an initiating party's transaction request has been lodged and the signatures validated, the transaction request is pooled in the blockchain network. Blockchain miners validate transactions and compete to discover a new block to be added to the blockchain. In order to add a newly discovered block to the blockchain, the blockchain miner must provide a cryptographic proof of the discovered block. To create the proof, the miner inputs the hash value of the prior block in the blockchain, the candidate block to be added, and a random number, commonly referred to as the nonce, to a hash function. The hash function takes input of any length and outputs an alphanumeric string of fixed length, commonly referred to as a hash, which uniquely identifies the input. However, the blockchain algorithm requires that the hash start with a certain number of leading zeros as determined by the current level of prescribed difficulty. The blockchain network modulates the level of difficulty for block discovery, by varying the number of leading zeros required in the calculated hash, based on the amount of computing power in the blockchain network.

[0005] As more computational capacity has come online, the hash rate has increased dramatically. In an effort to keep the block discovery time constant, the blockchain network modulates difficulty every 2016 blocks discovered. If the blockchain network hash rate is too high and the amount of time taken to discover a new block is less than 10 minutes, the difficulty is increased proportionally to increase the block discovery time to 10 minutes. Similarly, if the blockchain hash rate is too low and the amount of time taken to discover a new block is more than 10 minutes, the difficulty is increased proportionally to reduce the block discovery time to 10 minutes. Because there is no way to predict what hash value a given set of input data will generate, miners often have to execute the hash function a substantial number of times, each time inputting a new nonce, to generate a new hash value.

When a miner is the first to obtain a hash value having the correct number of leading zeros, they broadcast the newly discovered block to the blockchain network and the blockchain is replicated across all nodes.

BRIEF SUMMARY OF THE INVENTION

[0006] According to one aspect of one or more embodiments of the present invention, a flexible datacenter includes a mobile container, a **behind-the-meter** power input system, a power distribution system, a datacenter control system, a plurality of computing systems, and a climate control system. The datacenter control system modulates power delivery to the plurality of computing systems based on unutilized behind-the-meter power availability or an operational directive.

[0007] According to one aspect of one or more embodiments of the present invention, a method of dynamic power delivery to a flexible datacenter using unutilized behind-the-meter power includes monitoring unutilized behind-the-meter power availability, determining **when** a datacenter ramp-up condition is met, enabling behind-the-meter power delivery to one or more computing systems when the datacenter ramp-up condition is met, and directing the one or more computing systems to perform predetermined computational operations.

[0008] Other aspects of the present invention **will** be apparent from the following description and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Figure 1 shows a computing system **in** accordance with one or more embodiments of the present invention.

[0010] Figure 2 shows a flexible datacenter in accordance with one or more embodiments of the present invention.

[0011] Figure 3 shows a three-phase power distribution of a flexible datacenter in accordance **with** one or more embodiments of the present invention.

[0012] Figure 4 shows a control distribution scheme of a flexible datacenter in accordance with one or more embodiments of the present invention.

[0013] Figure 5 shows a control distribution scheme of a fleet of flexible datacenters in accordance with one or more embodiments of the present invention.

[0014] Figure 6 show's a flexible datacenter **powered** by one or more wind turbines in accordance with one or more embodiments of the present invention.

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[0015] Figure 7 shows a flexible datacenter powered by one or more solar panels in accordance with one or more embodiments of the present invention.

[0016] Figure 8 shows a flexible datacenter powered by flare gas in accordance with one or more embodiments of the present invention.

[0017] Figure 9 shows a method of dynamic power delivery to a flexible datacenter using unutilized behind-the-meter power in accordance with one or more embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0018] One or more embodiments of the present invention are described in detail with reference to the accompanying figures. For consistency, like elements in the various figures are denoted by like reference numerals. In the following detailed description of the present invention, specific details are set forth in order to provide a thorough understanding of the present invention. In other instances, well-known features to one having ordinary skill in the art are not described to avoid obscuring the description of the present invention.

[0019] Blockchain miners are typically compensated for their efforts through either a discoverer fee or a fee paid by one or more of the transacting parties. Consequently, more and more computing resources are coming online to compete for these fees. As the number of computing resources increases, the blockchain network modulates the difficulty level, requiring hash values with more leading zeros. In essence, the increased difficulty means more hashing operations are required to find a valid hash. As such, there is an increasing number of computing resources executing an increasing number of hash functions that do not result in the discovery of a valid hash, yet still consume a substantial amount of power.

[0020] The intensive computational demand of blockchain applications makes the widespread adoption of blockchain technology inefficient and unsustainable from an energy and environmental perspective. In certain blockchain applications, with limited participation, roughly 5 quintillion 256-bit cryptographic hashes are created each and every second of every day. While it is difficult to determine how much energy is required for that computational task, it is estimated to be in excess of 500 megawatts, the vast majority of which is sourced from fossil fuels. The majority of blockchain mining operations are currently being conducted in the People's Republic of China and powered by coal-fired energy. As blockchain technology

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proliferates, there is concern that the energy required to sustain such blockchain applications could exceed that of a developed country.

[0021] While future versions of blockchain technology may improve power consumption for various blockchain operations, including hashing functions, industry' efforts have focused on the development of central processing units ("CPUs"), graphics processing units ("GPUs"), and application specific integrated circuits ("ASICs") that are specifically designed to perform blockchain operations in a more efficient manner. While such efforts are beneficial, the issue remains, the widespread adoption of blockchain technology will require substantially more power than is economically and environmentally feasible.

[0022] Accordingly, in one or more embodiments of the present invention, a method and system for dynamic power delivery' to a flexible datacenter uses unutilized behind-the-meter power sources without transmission and distribution costs. The flexible datacenter may be configured to modulate power delivery to one or more computing systems based on the availability of unutilized behind-the-meter power or an operational directive. For example, the flexible datacenter may ramp-up to a fully online status, ramp-down to a fully offline status, or dynamically reduce power consumption, act a load balancer, or adjust the power factor. Advantageously, the flexible datacenter may perform computational operations, such as blockchain hashing operations, with little to no energy costs, using clean and renewable energy that would otherwise be wasted.

[0023] Figure 1 shows a computing system 100 in accordance with one or more embodiments of the present invention. Computing system 100 may include one or more central processing units (singular "CPU" or plural "CPUs") 105, host bridge 110, input/output ("IO") bridge 115, graphics processing units (singular "GPU" or plural "GPUs") 125, and/or application-specific integrated circuits (singular "ASIC" or plural "ASICs") (not shown) disposed on one or more printed circuit boards (not shown) that are configured to perform computational operations. Each of the one or more CPUs 105, GPUs 125, or ASICs (not shown) may be a single-core (not independently illustrated) device or a multi-core (not independently illustrated) device. Multi-core devices typically include a plurality of cores (not shown) disposed on the same physical die (not shown) or a plurality of cores (not shown) disposed on multiple die (not shown) that are collectively disposed within the same mechanical package (not shown).

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[0024] CPU 105 may be a general purpose computational device typically configured to execute software instructions. CPU 105 may include an interface 108 to host bridge 110, an interface 118 to system memory 120, and an interface 123 to one or more IO devices, such as, for example, one or more GPUs 125. GPU 125 may serve as a specialized computational device typically configured to perform graphics functions related to frame buffer manipulation. However, one of ordinary skill in the art will recognize that GPU 125 may be used to perform non-graphics related functions that are computationally intensive. In certain embodiments, GPU 125 may interface 123 directly with CPU 105 (and interface 118 with system memory 120 through CPU 105). In other embodiments, GPU 125 may interface 121 with host bridge 110 (and interface 116 or 118 with system memory 120 through host bridge 110 or CPU 105 depending on the application or design). In still other embodiments, GPU 125 may interface 133 with IO bridge 115 (and interface 116 or 118 with system memory 120 through host bridge 110 or CPU 105 depending on the application or design). The functionality of GPU 125 may be integrated, in whole or in part, with CPU 105.

[0025] Host bridge 110 may be an interface device configured to interface between the one or more computational devices and IO bridge 115 and, in some embodiments, system memory 120. Host bridge 110 may include an interface 108 to CPU 105, an interface 113 to IO bridge 115, for embodiments where CPU 105 does not include an interface 118 to system memory 120, an interface 116 to system memory 120, and for embodiments where CPU 105 does not include an integrated GPU 125 or an interface 123 to GPU 125, an interface 121 to GPU 125. The functionality of host bridge 110 may be integrated, in whole or in part, with CPU 105. IO bridge 115 may be an interface device configured to interface between the one or more computational devices and various IO devices (*e.g.*, 140, 145) and IO expansion, or add-on, devices (not independently illustrated). IO bridge 115 may include an interface 113 to host bridge 110, one or more interfaces 133 to one or more IO expansion devices 135, an interface 138 to keyboard 140, an interface 143 to mouse 145, an interface 148 to one or more local storage devices 150, and an interface 153 to one or more network interface devices 155. The functionality of IO bridge 115 may be integrated, in whole or in part, with CPU 105 or host bridge 110. Each local storage device 150, if any, may be a solid-state memory device, a solid-state memory device array, a hard disk drive, a hard disk drive array, or any other

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non-transitory computer readable medium. Network interface device 155 may provide one or more network interfaces including any network protocol suitable to facilitate networked communications.

[0026] Computing system 100 may include one or more network-attached storage devices 160 in addition to, or instead of, one or more local storage devices 150. Each network-attached storage device 160, if any, may be a solid-state memory device, a solid-state memory device array, a hard disk drive, a hard disk drive array, or any other non-transitory computer readable medium. **Network-attached** storage device 160 may or may **not** be collocated **with** computing system 100 and may be accessible to computing system 100 via one or more **network** interfaces provided by one or more **network** interface devices 155.

[0027] One of ordinary skill in the art **will** recognize that computing system 100 may be a conventional computing system or an application-specific computing system. **In** certain embodiments, an application-specific computing system may include one or more ASICs (not shown) that are configured to perform one or more functions, such as hashing, in a more efficient manner. The one or more ASICs (not shown) may interface directly with CPU 105, host bridge 110, or GPU 125 or interface through IO bridge **115**. Alternatively, **in** other embodiments, an application-specific computing system may be reduced to only those components **necessary** to perform a desired function in an effort to reduce one or more of chip count, printed circuit board footprint, thermal design power, and power consumption. The one or more ASICs (not shown) may be used instead of one or more of CPU 105, host bridge **110**, IO bridge **115**, or GPU 125. **In** such systems, the one or more ASICs may incorporate sufficient functionality to perform certain network and computational functions in a minimal footprint **with** substantially fewer component devices.

[0028] As such, one of **ordinary** skill in the art will recognize that CPU 105, host bridge **110**, IO bridge **115**, GPU 125, or ASIC (not shown) or a subset, superset, or combination of functions or features thereof, may be integrated, distributed, or excluded, in whole or in part, based on an application, design, or **form** factor in accordance with one or more embodiments of the present invention. Thus, the description of computing system 100 is merely exemplary and not intended to **limit** the **type**, kind, or configuration of component devices that constitute a computing system 100 suitable for performing computing operations in accordance with one or more embodiments of the present invention.

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[0029] One of ordinary skill in the art will recognize that computing system 100 may be a stand alone, laptop, desktop, server, blade, or rack mountable system and may vary based on an application or design.

[0030] Figure 2 shows a flexible datacenter 200 in accordance with one or more embodiments of the present invention. Flexible datacenter 200 may include a mobile container 205, a behind-the-meter power input system 210, a power distribution system **215**, a climate control system (*e.g.*, 250, 260, 270, 280, and/or 290), a datacenter control system 220, and a plurality of computing systems 100 disposed in one or more racks 240. Datacenter control system 220 may be a computing system (*e.g.*, 100 of Figure 1) configured to dynamically modulate power delivery to one or more computing systems 100 disposed within flexible datacenter 200 based on unutilized behind-the-meter power availability or an operational directive from a local station control system (not shown), a remote master control system (not shown), or a grid operator (not shown).

[0031] In certain embodiments, mobile container 205 may be a storage trailer disposed on wheels and configured for rapid deployment. In other embodiments, mobile container 205 may be a storage container (not shown) configured for placement on the ground and potentially stacked in a vertical manner (not shown). In still other embodiments, mobile container 205 may be an inflatable container, a floating container, or any other type or kind of container suitable for housing a mobile datacenter 200.

[0032] Flexible datacenter 200 may be rapidly deployed on site near a source of unutilized behind-the-meter power generation. Behind-the-meter power input system 210 may be configured to input power to flexible datacenter 200. Behind-the-meter power input system 210 may include a first input (not independently illustrated) configured to receive three-phase behind-the-meter alternating current (“AC”) voltage. In certain embodiments, behind-the-meter power input system 210 may include a supervisory AC-to-AC step-down transformer (not shown) configured to step down three-phase behind-the-meter AC voltage to single-phase supervisory nominal AC voltage or a second input (not independently illustrated) configured to receive single-phase supervisory nominal AC voltage from the local station (not shown) or a metered source (not shown). Behind-the-meter power input system 210 may provide single-phase supervisory nominal AC voltage to datacenter control system 220, which may remain powered at almost all times to control the

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operation of flexible datacenter 200. The first input (not independently illustrated) or a third input (not independently illustrated) of behind-the-meter power input system 210 may direct three-phase behind-the-meter AC voltage to an operational AC-to-AC step-down transformer (not shown) configured to controllably step down three-phase behind-the-meter AC voltage to three-phase nominal AC voltage. Datacenter control system 220 may controllably enable or disable generation or provision of three-phase nominal AC voltage by the operational AC-to-AC step-down transformer (not shown).

[0033] Behind-the-meter power input system 210 may provide three phases of three-phase nominal AC voltage to power distribution system 215. Power distribution system 215 may controllably provide a single phase of three-phase nominal AC voltage to each computing system 100 or group 240 of computing systems **100** disposed within flexible datacenter 200. Datacenter control system 220 may controllably select which phase of three-phase nominal AC voltage that power distribution system 215 provides to each computing system 100 or group 240 of computing systems 100. In this way, datacenter control system 220 may modulate power delivery by either ramping-up flexible datacenter 200 to fully operational status, ramping-down flexible datacenter 200 to offline status (where only datacenter control system 220 remains powered), reducing power consumption by withdrawing power delivery from, or reducing power to, one or more computing systems 100 or groups 240 of computing systems 100, or modulating a power factor correction factor for the local station by controllably adjusting which phases of three-phase nominal AC voltage are used by one or more computing systems 100 or groups 240 of computing systems 100.

[0034] Flexible datacenter 200 may include a climate control system (*e.g.*, 250, 260, 270, 280, 290) configured to maintain the plurality of computing systems 100 within their operational temperature range. In certain embodiments, the climate control system may include an air intake 250, an evaporative cooling system 270, a fan 280, and an air outtake 260. In other embodiments, the climate control system may include an air intake 250, an air conditioner or refrigerant cooling system 290, and an air outtake 260. In still other embodiments, the climate control system may include a computer room air conditioner system (not shown), a computer room air handler system (not shown), or an immersive cooling system (not shown). One of ordinary skill in the art will recognize that any suitable heat extraction system (not

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shown) configured to maintain the operation of the plurality of computing systems 100 within their operational temperature range may be used in accordance with one or more embodiments of the present invention.

[0035] Flexible datacenter 200 may include a battery' system (not shown) configured to convert three-phase nominal AC voltage to nominal DC voltage and store power in a plurality of storage cells. The battery' system (not shown) may include a DC-to-AC inverter configured to convert nominal DC voltage to three-phase nominal AC voltage for flexible datacenter 200 use. Alternatively, the battery system (not shown) may include a DC-to-AC inverter configured to convert nominal DC voltage to single-phase nominal AC voltage to power datacenter control system 220.

[0036] One of ordinary skill in the art will recognize that a voltage level of three-phase behind-the-meter AC voltage may vary based on an application or design and the type or kind of local power generation. As such, a type, kind, or configuration of the operational AC-to-AC step down transformer (not shown) may vary based on the application or design. In addition, the frequency and voltage level of three-phase nominal AC voltage, single-phase nominal AC voltage, and nominal DC voltage may vary based on the application or design in accordance with one or more embodiments of the present invention.

[0037] Figure 3 shows a three-phase power distribution of a flexible datacenter 200 in accordance with one or more embodiments of the present invention. Flexible datacenter 200 may include a plurality of racks 240, each of which may include one or more computing systems 100 disposed therein. As discussed above, the behind-the-meter power input system (210 of Figure 2) may provide three phases of three-phase nominal AC voltage to the power distribution system (215 of Figure 2). The power distribution system (215 of Figure 2) may controllably provide a single phase of three-phase nominal AC voltage to each computing system 100 or group 240 of computing systems 100 disposed within flexible datacenter 200. For example, a flexible datacenter 200 may include eighteen racks 240, each of which may include eighteen computing systems 100. The power distribution system (215 of Figure 2) may control which phase of three-phase nominal AC voltage is provided to one or more computing systems 100, a rack 240 of computing systems 100, or a group (*e.g.*, 310, 320, or 330) of racks 240 of computing systems 100.

[0038] In the figure, for purposes of illustration only, eighteen racks 240 are divided into a first group of six racks 310, a second group of six racks 320, and a third group

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of six racks 330, where each rack contains eighteen computing systems 100. The power distribution system (215 of Figure 2) may, for example, provide a first phase of three-phase nominal AC voltage to the first group of six racks 310, a second phase of three-phase nominal AC voltage to the second group of six racks 320, and a third phase of three-phase nominal AC voltage to the third group of six racks 330. If the flexible datacenter (200 of Figure 2) receives an operational directive from the local station (not shown) to provide power factor correction, the datacenter control system (220 of Figure 2) may direct the power distribution system (215 of Figure 2) to adjust which phase or phases of three-phase nominal AC voltage are used to provide the power factor correction required by the local station (not shown) or grid operator (not shown). One of ordinary skill in the art will recognize that, in addition to the power distribution, the load may be varied by adjusting the number of computing systems 100 operatively powered. As such, the flexible datacenter (200 of Figure 2) may be configured to act as a capacitive or inductive load to provide the appropriate reactance necessary to achieve the power factor correction required by the local station (not shown).

[0039] Figure 4 shows a control distribution scheme of a flexible datacenter 200 in accordance with one or more embodiments of the present invention. Datacenter control system 220 may independently, or cooperatively with one or more of local station control system 410, remote master control system 420, and grid operator 440, modulate power delivery to flexible datacenter 200. Specifically, power delivery may be dynamically adjusted based on conditions or operational directives.

[0040] Local station control system 410 may be a computing system (*e.g.*, 100 of Figure 1) that is configured to control various aspects of the local station (not independently illustrated) that generates power and sometimes generates unutilized behind-the-meter power. Local station control system 410 may communicate with remote master control system 420 over a networked connection 430 and with datacenter control system 220 over a networked or hardwired connection 415. Remote master control system 420 may be a computing system (*e.g.*, 100 of Figure 1) that is located offsite, but connected via a network connection 425 to datacenter control system 220, that is configured to provide supervisory or override control of flexible datacenter 200 or a fleet (not shown) of flexible datacenters 200. Grid operator 440 may be a computing system (*e.g.*, 100 of Figure 1) that is configured to control various aspects of the grid (not independently illustrated) that receives

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power from the local station (not independently illustrated). Grid operator 440 may communicate with local station control system 440 over a networked or hardwired connection 445.

[0041] Datacenter control system 220 may monitor unutilized behind-the-meter power availability at the local station (not independently illustrated) and determine when a datacenter ramp-up condition is met. Unutilized behind-the-meter power availability may include one or more of excess local power generation, excess local power generation that the grid cannot accept, local power generation that is subject to economic curtailment, local power generation that is subject to reliability curtailment, local power generation that is subject to power factor correction, situations where local power generation is prohibitively low, start up situations, transient situations, or testing situations where there is an economic advantage to using locally generated behind-the-meter power generation, specifically power available at little to no cost and with no associated transmission or distribution costs.

[0042] The datacenter ramp-up condition may be met if there is sufficient behind-the-meter power availability and there is no operational directive from local station control system 410, remote master control system 420, or grid operator 440 to go offline or reduce power. As such, datacenter control system 220 may enable 435 behind-the-meter power input system 210 to provide three-phase nominal AC voltage to the power distribution system (215 of Figure 2) to power the plurality of computing systems (100 of Figure 2) or a subset thereof. Datacenter control system 220 may optionally direct one or more computing systems (100 of Figure 2) to perform predetermined computational operations. For example, if the one or more computing systems (100 of Figure 2) are configured to perform blockchain hashing operations, datacenter control system 220 may direct them to perform blockchain hashing operations for a specific blockchain application, such as, for example, Bitcoin, Litecoin, or Ethereum. Alternatively, one or more computing systems (100 of Figure 2) may be configured to independently receive a computational directive from a network connection (not shown) to a peer-to-peer blockchain network (not shown) such as, for example, a network for a specific blockchain application, to perform predetermined computational operations.

[0043] Remote master control system 420 may specify to datacenter control system 220 what sufficient behind-the-meter power availability constitutes, or datacenter

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control system 220 may be programmed with a predetermined preference or criteria on which to make the determination independently. For example, in certain circumstances, sufficient behind-the-meter power availability may be less than that required to fully power the entire flexible datacenter 200. In such circumstances, datacenter control system 220 may provide power to only a subset of computing systems (100 of Figure 2), or operate the plurality of computing systems (100 of Figure 2) in a lower power mode, that is within the sufficient, but less than full, range of power that is available.

[0044] While flexible datacenter 200 is online and operational, a datacenter ramp-down condition may be met when there is insufficient, or anticipated to be insufficient, behind-the-meter power availability or there is an operational directive from local station control system **410**, remote master control system 420, or grid operator 440. Datacenter control system 220 may monitor and determine when there is insufficient, or anticipated to be insufficient, behind-the-meter power availability. As noted above, sufficiency may be specified by remote master control system 420 or datacenter control system 220 may be programmed with a predetermined preference or criteria on which to make the determination independently. An operational directive may be based on current dispatchability, forward looking forecasts for when unutilized behind-the-meter power is, or is expected to be, available, economic considerations, reliability considerations, operational considerations, or the discretion of the local station 410, remote master control 420, or grid operator 440. For example, local station control system 410, remote master control system 420, or grid operator 440 may issue an operational directive to flexible datacenter 200 to go offline and power down. When the datacenter ramp-down condition is met, datacenter control system 220 may disable power delivery to the plurality of computing systems (100 of Figure 2). Datacenter control system 220 may disable 435 behind-the-meter power input system 210 from providing three-phase nominal AC voltage to the power distribution system (215 of Figure 2) to power down the plurality of computing systems (100 of Figure 2), while datacenter control system 220 remains powered and is capable of rebooting flexible datacenter 200 when unutilized behind-the-meter power becomes available again.

[0045] While flexible datacenter 200 is online and operational, changed conditions or an operational directive may cause datacenter control system 220 to modulate power consumption by flexible datacenter 200. Datacenter control system 220 may

determine, or local station control system 410, remote master control system 420, or grid operator 440 may communicate, that a change in local conditions may result in less power generation, availability, or economic feasibility, than would be necessary to fully power flexible datacenter 200. In such situations, datacenter control system 220 may take steps to reduce or stop power consumption by flexible datacenter 200 (other than that required to maintain operation of datacenter control system 220). Alternatively, local station control system 410, remote master control system 420, or grid operator 440, may issue an operational directive to reduce power consumption for any reason, the cause of which may be unknown. In response, datacenter control system 220 may dynamically reduce or withdraw power delivery to one or more computing systems (100 of Figure 2) to meet the dictate. Datacenter control system 220 may controllably provide three-phase nominal AC voltage to a smaller subset of computing systems (100 of Figure 2) to reduce power consumption. Datacenter control system 220 may dynamically reduce the power consumption of one or more computing systems (100 of Figure 2) by reducing their operating frequency or forcing them into a lower power mode through a network directive.

[0046] One of ordinary skill in the art will recognize that datacenter control system 220 may be configured to have a number of different configurations, such as a number or type or kind of computing systems (100 of Figure 2) that may be powered, and in what operating mode, that correspond to a number of different ranges of sufficient and available unutilized behind-the-meter power availability. As such, datacenter control system 220 may modulate power delivery over a variety of ranges of sufficient and available unutilized behind-the-meter power availability.

[0047] Figure 5 shows a control distribution of a fleet 500 of flexible datacenters 200 in accordance with one or more embodiments of the present invention. The control distribution of a flexible datacenter 200 shown and described with respect to Figure 4 may be extended to a fleet 500 of flexible datacenters 200. For example, a first local station (not independently illustrated), such as, for example, a wind farm (not shown), may include a first plurality 510 of flexible datacenters 200a through 200d, which may be collocated or distributed across the local station (not shown). A second local station (not independently illustrated), such as, for example, another wind farm or a solar farm (not shown), may include a second plurality 520 of flexible datacenters 200e through 200/y which may be collocated or distributed

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across the local station (not shown). One of ordinary skill in the art will recognize that the number of flexible datacenters 200 deployed at a given station and the number of stations within the fleet may vary based on an application or design in accordance with one or more embodiments of the present invention.

[0048] Remote master control system 420 may provide supervisory control over fleet 500 of flexible datacenters 200 in a similar manner to that shown and described with respect to Figure 4, with the added flexibility to make high level decisions with respect to fleet 500 that may be counterintuitive to a given station. Remote master control system 420 may make decisions regarding the issuance of operational directives to a given local station based on, for example, the status of each local station where flexible datacenters 200 are deployed, the workload distributed across fleet 500, and the expected computational demand required for the expected workload. In addition, remote master control system 420 may shift workloads from a first plurality 510 of flexible datacenters 200 to a second plurality 520 of flexible datacenters 200 for any reason, including, for example, a loss of unutilized behind-the-meter power availability at one local station and the availability of unutilized behind-the-meter power at another local station.

[0049] Figure 6 shows a flexible datacenter 200 powered by one or more wind turbines 610 in accordance with one or more embodiments of the present invention. A wind farm 600 typically includes a plurality of wind turbines 610, each of which intermittently generates a wind-generated AC voltage. The wind-generated AC voltage may vary based on a type, kind, or configuration of farm 600, turbine 610, and incident wind speed. The wind-generated AC voltage is typically input into a turbine AC-to-AC step-up transformer (not shown) that is disposed within the nacelle (not independently illustrated) or at the base of the mast (not independently illustrated) of turbine 610. The turbine AC-to-AC step up transformer (not shown) outputs three-phase wind-generated AC voltage 620. Three-phase wind-generated AC voltage 620 produced by the plurality of wind turbines 610 is collected 625 and provided 630 to another AC-to-AC step-up transformer 640 that steps up three-phase wind-generated AC voltage 620 to three-phase grid AC voltage 650 suitable for delivery to grid 660. Three-phase grid AC voltage 650 may be stepped down with an AC-to-AC step-down transformer 670 configured to produce three-phase local station AC voltage 680 provided to local station 690. One of ordinary skill in the art will recognize that the actual voltage levels may vary based on the type, kind,

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or number of wind turbines 610, the configuration or design of wind farm 600, and grid 660 that it feeds into.

[0050] The output side of AC-to-AC step-up transformer 640 that connects to grid 660 may be metered and is typically subject to transmission and distribution costs. In contrast, power consumed on the input side of AC-to-AC step-up transformer 640 may be considered behind-the-meter and is typically not subject to transmission and distribution costs. As such, one or more flexible datacenters 200 may be powered by three-phase wind-generated AC voltage 620. Specifically, in wind farm 600 applications, the three-phase behind-the-meter AC voltage used to power flexible datacenter 200 may be three-phase wind-generated AC voltage 620. As such, flexible datacenter 200 may reside behind-the-meter, avoid transmission and distribution costs, and may be dynamically powered when unutilized behind-the-meter power is available.

[0051] Unutilized behind-the-meter power availability may occur when there is excess local power generation. In high wind conditions, wind farm 600 may generate more power than, for example, AC-to-AC step-up transformer 640 is rated for. In such situations, wind farm 600 may have to take steps to protect its equipment from damage, which may include taking one or more turbines 610 offline or shunting their voltage to dummy loads or ground. Advantageously, one or more flexible datacenters 200 may be used to consume power on the input side of AC-to-AC step-up transformer 640, thereby allowing wind farm 600 to operate equipment within operating ranges while flexible datacenter 200 receives behind-the-meter power without transmission or distribution costs. The local station control system (not independently illustrated) of local station 690 may issue an operational directive to the one or more flexible datacenters 200 or to the remote master control system (420 of Figure 4) to ramp-up to the desired power consumption level. When the operational directive requires the cooperative action of multiple flexible datacenters 200, the remote master control system (420 of Figure 4) may determine how to power each individual flexible datacenter 200 in accordance with the operational directive or provide an override to each flexible datacenter 200.

[0052] Another example of unutilized behind-the-meter power availability is when grid 660 cannot, for whatever reason, take the power being produced by wind farm 600. In such situations, wind farm 600 may have to take one or more turbines 610 offline or shunt their voltage to dummy loads or ground. Advantageously, one or

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more flexible datacenters 200 may be used to consume power on the input side of AC-to-AC step-up transformer 640, thereby allowing wind farm 600 to either produce power to grid 660 at a lower level or shut down transformer 640 entirely while flexible datacenter 200 receives behind-the-meter power without transmission or distribution costs. The local station control system (not independently illustrated) of local station 690 or the grid operator (not independently illustrated) of grid 660 may issue an operational directive to the one or more flexible datacenters 200 or to the remote master control system (420 of Figure 4) to ramp-up to the desired power consumption level. When the operational directive requires the cooperative action of multiple flexible datacenters 200, the remote master control system (420 of Figure 4) may determine how to power each individual flexible datacenter 200 in accordance with the operational directive or provide an override to each flexible datacenter 200.

[0053] Another example of unutilized behind-the-meter power availability is when wind farm 600 is selling power to grid 660 at a negative price that is offset by a production tax credit. In certain circumstances, the value of the production tax credit may exceed the price wind farm 600 would have to pay to grid 660 to offload their generated power. Advantageously, one or more flexible datacenters 200 may be used to consume power behind-the-meter, thereby allowing wind farm 600 to produce and obtain the production tax credit, but sell less power to grid 660 at the negative price. The local station control system (not independently illustrated) of local station 690 may issue an operational directive to the one or more flexible datacenters 200 or to the remote master control system (420 of Figure 4) to ramp-up to the desired power consumption level. When the operational directive requires the cooperative action of multiple flexible datacenter 200, the remote master control system (420 of Figure 4) may determine how to power each individual flexible datacenter 200 in accordance with the operational directive or provide an override to each flexible datacenter 200.

[0054] Another example of unutilized behind-the-meter power availability is when wind farm 600 is selling power to grid 660 at a negative price because grid 660 is oversupplied or is instructed to stand down and stop producing altogether. The grid operator (not independently illustrated) may select certain power generation stations to go offline and stop producing power to grid 660. Advantageously, one or more flexible datacenters 200 may be used to consume power behind-the-meter, thereby

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allowing wind farm 600 to stop producing power to grid 660, but making productive use of the power generated behind-the-meter without transmission or distribution costs. The local station control system (not independently illustrated) of the local station 690 or the grid operator (not independently illustrated) of grid 660 may issue an operational directive to the one or more flexible datacenters 200 or to the remote master control system (420 of Figure 4) to ramp-up to the desired power consumption level. When the operational directive requires the cooperative action of multiple flexible datacenters 200, the remote master control system (420 of Figure 4) may determine how to power each individual flexible datacenter 200 in accordance with the operational directive or provide an override to each flexible datacenter 200.

[0055] Another example of unutilized behind-the-meter power availability is when wind farm 600 is producing power to grid 660 that is unstable, out of phase, or at the wrong frequency, or grid 660 is already unstable, out of phase, or at the wrong frequency for whatever reason. The grid operator (not independently illustrated) may select certain power generation stations to go offline and stop producing power to grid 660. Advantageously, one or more flexible datacenters 200 may be used to consume power behind-the-meter, thereby allowing wind farm 600 to stop producing power to grid 660, but make productive use of the power generated behind-the-meter without transmission or distribution costs. The local station control system (not independently illustrated) of local station 690 may issue an operational directive to the one or more flexible datacenters 200 or to the remote master control system (420 of Figure 4) to ramp-up to the desired power consumption level. When the operational directive requires the cooperative action of multiple flexible datacenters 200, the remote master control system (420 of Figure 4) may determine how to power each individual flexible datacenter 200 in accordance with the operational directive or provide an override to each flexible datacenter 200.

[0056] Further examples of unutilized behind-the-meter power availability is when wind farm 600 experiences low wind conditions that make it not economically feasible to power up certain components, such as, for example, the local station (not independently illustrated), but there may be sufficient behind-the-meter power availability to power one or more flexible datacenters 200. Similarly, unutilized behind-the-meter power availability may occur when wind farm 600 is starting up,

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or testing, one or more turbines 610. Turbines 610 are frequently offline for installation, maintenance, and sendee and must be tested prior to coming online as part of the array. One or more flexible datacenters 200 may be powered by one or more turbines 610 that are offline from farm 600. The above-noted examples of when unutilized behind-the-meter power is available are merely exemplary and are not intended to limit the scope of what one of ordinary skill in the art would recognize as unutilized behind-the-meter power availability. Unutilized behind-the-meter power availability may occur anytime there is power available and accessible behind-the-meter that is not subject to transmission and distribution costs and there is an economic advantage to using it.

[0057] One of ordinary skill in the art will recognize that wind farm 600 and wind turbine 610 may vary based on an application or design in accordance with one or more embodiments of the present invention.

[0058] Figure 7 shows a flexible datacenter 200 powered by one or more solar panels 710 in accordance with one or more embodiments of the present invention. A solar farm 700 typically includes a plurality of solar panels 710, each of which intermittently generates a solar-generated DC voltage 720. Solar-generated DC voltage 720 may vary based on a type, kind, or configuration of farm 700, panel 710, and incident sunlight. Solar-generated DC voltage 720 produced by the plurality of solar panels 710 is collected 725 and provided 730 to a DC-to-AC inverter that converts solar-generated DC voltage into three-phase solar-generated AC voltage 750. Three-phase solar-generated AC voltage 750 is provided to an AC-to-AC step-up transformer 760 that steps up three-phase solar-generated AC voltage to three-phase grid AC voltage 790. Three-phase grid AC voltage 790 may be stepped down with an AC-to-AC step-down transformer 785 configured to produce three-phase local station AC voltage 777 provided to local station 775. One of ordinary skill in the art will recognize that the actual voltage levels may vary' based on the type, kind, or number of solar panels 710, the configuration or design of solar farm 700, and grid 790 that it feeds into.

[0059] The output side of AC-to-AC step-up transformer 760 that connects to grid 790 may be metered and is typically subject to transmission and distribution costs. In contrast, power consumed on the input side of AC-to-AC step-up transformer 760 may be considered behind-the-meter and is typically not subject to transmission and distribution costs. As such, one or more flexible datacenters 200 may be powered by

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three-phase solar-generated AC voltage 750. Specifically, in solar farm 700 applications, the three-phase behind-the-meter AC voltage used to power flexible datacenter 200 may be three-phase solar-generated AC voltage 750. As such, flexible datacenter 200 may reside behind-the-meter, avoid transmission and distribution costs, and may be dynamically powered when unutilized behind-the-meter power is available.

[0060] Unutilized behind-the-meter power availability may occur when there is excess local power generation. In high incident sunlight situations, solar farm 700 may generate more power than, for example, AC-to-AC step-up transformer 760 is rated for. In such situations, solar farm 700 may have to take steps to protect its equipment from damage, which may include taking one or more panels 710 offline or shunting their voltage to dummy loads or ground. Advantageously, one or more flexible datacenters 200 may be used to consume power on the input side of AC-to-AC step-up transformer 760, thereby allowing solar farm 700 to operate equipment within operating ranges while flexible datacenter 200 receives behind-the-meter power without transmission or distribution costs. The local station control system (not independently illustrated) of local station 775 may issue an operational directive to the one or more flexible datacenters 200 or to the remote master control system (420 of Figure 4) to ramp-up to the desired power consumption level. When the operational directive requires the cooperative action of multiple flexible datacenters 200, the remote master control system (420 of Figure 4) may determine how to power each individual flexible datacenter 200 in accordance with the operational directive or provide an override to each flexible datacenter 200.

[0061] Another example of unutilized behind-the-meter power availability is when grid 790 cannot, for whatever reason, take the power being produced by solar farm 700. In such situations, solar farm 700 may have to take one or more panels 710 offline or shunt their voltage to dummy loads or ground. Advantageously, one or more flexible datacenters 200 may be used to consume power on the input side of AC-to-AC step-up transformer 760, thereby allowing solar farm 700 to either produce power to grid 790 at a lower level or shut down transformer 760 entirely while flexible datacenter 200 receives behind-the-meter power without transmission or distribution costs. The local station control system (not independently illustrated) of local station 775 or the grid operator (not independently illustrated) of grid 790 may issue an operational directive to the one or more flexible datacenters 200 or to

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the remote master control system (420 of Figure 4) to ramp-up to the desired power consumption level. When the operational directive requires the cooperative action of multiple flexible datacenters 200, the remote master control system (420 of Figure 4) may determine how to power each individual flexible datacenter 200 in accordance with the operational directive or provide an override to each flexible datacenter 200.

[0062] Another example of unutilized behind-the-meter power availability is when solar farm 700 is selling power to grid 790 at a negative price that is offset by a production tax credit. In certain circumstances, the value of the production tax credit may exceed the price solar farm 700 would have to pay to grid 790 to offload their generated power. Advantageously, one or more flexible datacenters 200 may be used to consume power behind-the-meter, thereby allowing solar farm 700 to produce and obtain the production tax credit, but sell less power to grid 790 at the negative price. The local station control system (not independently illustrated) of local station 775 may issue an operational directive to the one or more flexible datacenters 200 or to the remote master control system (420 of Figure 4) to ramp-up to the desired power consumption level. When the operational directive requires the cooperative action of multiple flexible datacenter 200, the remote master control system (420 of Figure 4) may determine how to power each individual flexible datacenter 200 in accordance with the operational directive or provide an override to each flexible datacenter 200.

[0063] Another example of unutilized behind-the-meter power availability is when solar farm 700 is selling power to grid 790 at a negative price because grid 790 is oversupplied or is instructed to stand down and stop producing altogether. The grid operator (not independently illustrated) may select certain power generation stations to go offline and stop producing power to grid 790. Advantageously, one or more flexible datacenters 200 may be used to consume power behind-the-meter, thereby allowing solar farm 700 to stop producing power to grid 790, but making productive use of the power generated behind-the-meter without transmission or distribution costs. The local station control system (not independently illustrated) of the local station 775 or the grid operator (not independently illustrated) of grid 790 may issue an operational directive to the one or more flexible datacenters 200 or to the remote master control system (420 of Figure 4) to ramp-up to the desired power consumption level. When the operational directive requires the cooperative action of

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multiple flexible datacenters 200, the remote master control system (420 of Figure 4) may determine how to power each individual flexible datacenter 200 in accordance with the operational directive or provide an override to each flexible datacenter 200.

[0064] Another example of unutilized behind-the-meter power availability is when solar farm 700 is producing power to grid 790 that is unstable, out of phase, or at the wrong frequency, or grid 790 is already unstable, out of phase, or at the wrong frequency for whatever reason. The grid operator (not independently illustrated) may select certain power generation stations to go offline and stop producing power to grid 790. Advantageously, one or more flexible datacenters 200 may be used to consume power behind-the-meter, thereby allowing solar farm 700 to stop producing power to grid 790, but make productive use of the power generated behind-the-meter without transmission or distribution costs. The local station control system (not independently illustrated) of local station 775 may issue an operational directive to the one or more flexible datacenters 200 or to the remote master control system (420 of Figure 4) to ramp-up to the desired power consumption level. When the operational directive requires the cooperative action of multiple flexible datacenters 200, the remote master control system (420 of Figure 4) may determine how to power each individual flexible datacenter 200 in accordance with the operational directive or provide an override to each flexible datacenter 200.

[0065] Further examples of unutilized behind-the-meter power availability is when solar farm 700 experiences intermittent cloud cover such that it is not economically feasible to power up certain components, such as, for example local station 775, but there may be sufficient behind-the-meter power availability to power one or more flexible datacenters 200. Similarly, unutilized behind-the-meter power availability may occur when solar farm 700 is starting up, or testing, one or more panels 710. Panels 710 are frequently offline for installation, maintenance, and service and must be tested prior to coming online as part of the array. One or more flexible datacenters 200 may be powered by one or more panels 710 that are offline from farm 700. The above-noted examples of when unutilized behind-the-meter power is available are merely exemplary and are not intended to limit the scope of what one of ordinary skill in the art would recognize as unutilized behind-the-meter power availability. Behind-the-meter power availability may occur anytime there is power

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available and accessible behind-the-meter that is not subject to transmission and distribution costs and there is an economic advantage to using it.

[0066] One of ordinary skill in the art will recognize that solar farm 700 and solar panel 710 may vary based on an application or design in accordance with one or more embodiments of the present invention.

[0067] Figure 8 shows a flexible datacenter 200 powered by flare gas 800 in accordance with one or more embodiments of the present invention. Flare gas 800 is combustible gas produced as a product or by-product of petroleum refineries, chemical plants, natural gas processing plants, oil and gas drilling rigs, and oil and gas production facilities. Flare gas 800 is typically burned off through a flare stack (not shown) or vented into the air. In one or more embodiments of the present invention, flare gas 800 may be diverted 812 to a gas-powered generator that produces three-phase gas-generated AC voltage 822. This power may be considered behind-the-meter and is not subject to transmission and distribution costs. As such, one or more flexible datacenters 200 may be powered by three-phase gas-generated AC voltage. Specifically, the three-phase behind-the-meter AC voltage used to power flexible datacenter 200 may be three-phase gas-generated AC voltage 822. Accordingly, flexible datacenter 200 may reside behind-the-meter, avoid transmission and distribution costs, and may be dynamically powered when unutilized behind-the-meter power is available.

[0068] Figure 9 shows a method of dynamic power delivery to a flexible datacenter (200 of Figure 2) using unutilized behind-the-meter power 900 in accordance with one or more embodiments of the present invention. In step 910, the datacenter control system (220 of Figure 4), or the remote master control system (420 of Figure 4), may monitor unutilized behind-the-meter power availability. In certain embodiments, monitoring may include receiving information or an operational directive from the local station control system (410 of Figure 4) or the grid operator (440 of Figure 4) corresponding to unutilized behind-the-meter power availability.

[0069] In step 920, the datacenter control system (220 of Figure 4), or the remote master control system (420 of Figure 4), may determine when a datacenter ramp-up condition is met. In certain embodiments, the datacenter ramp-up condition may be met when there is sufficient behind-the-meter power availability and there is no operational directive from the local station to go offline or reduce power. In step 930, the datacenter control system (220 of Figure 4) may enable behind-the-meter

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power delivery to one or more computing systems (100 of Figure 2). In step 940, once ramped-up, the datacenter control system (220 of Figure 4) or the remote master control system (420 of Figure 4) may direct one or more computing systems (100 of Figure 2) to perform predetermined computational operations. In certain embodiments, the predetermined computational operations may include the execution of one or more hashing functions.

[0070] While operational, the datacenter control system (220 of Figure 4), or the remote master control system (420 of Figure 4), may receive an operational directive to modulate power consumption. In certain embodiments, the operational directive may be a directive to reduce power consumption. In such embodiments, the datacenter control system (220 of Figure 4) or the remote master control system (420 of Figure 4) may dynamically reduce power delivery to one or more computing systems (100 of Figure 2) or dynamically reduce power consumption of one or more computing systems. In other embodiments, the operational directive may be a directive to provide a power factor correction factor. In such embodiments, the datacenter control system (220 of Figure 4) or the remote master control system (420 of Figure 4) may dynamically adjust power delivery to one or more computing systems (100 of Figure 2) to achieve a desired power factor correction factor. In still other embodiments, the operational directive may be a directive to go offline or power down. In such embodiments, the datacenter control system (220 of Figure 4) may disable power delivery to one or more computing systems (100 of Figure 2).

[0071] The datacenter control system (220 of Figure 4), or the remote master control system (420 of Figure 4), may determine when a datacenter ramp-down condition is met. In certain embodiments, the datacenter ramp-down condition may be met if there is insufficient or anticipated to be insufficient behind-the-meter power availability or there is an operational directive from the local station to go offline or reduce power. The datacenter control system (220 of Figure 4) may disable behind-the-meter power delivery to one or more computing systems (100 of Figure 2). Once ramped-down, the datacenter control system (220 of Figure 4) remains powered and in communication with the remote master control system (420 of Figure 4) so that it may dynamically power the flexible datacenter (200 of Figure 2) when conditions change.

[0072] One of ordinary skill in the art will recognize that a datacenter control system (220 of Figure 4) may dynamically modulate power delivery' to one or more

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computing systems (100 of Figure 2) of a flexible datacenter (200 of Figure 2) based on unutilized behind-the-meter power availability or an operational directive. The flexible datacenter (200 of Figure 2) may transition between a fully powered down state (while the datacenter control system remains powered), a fully powered up state, and various intermediate states in between. In addition, flexible datacenter (200 of Figure 2) may have a blackout state, where all power consumption, including that of the datacenter control system (220 of Figure 4) is halted. However, once the flexible datacenter (200 of Figure 2) enters the blackout state, it will have to be manually rebooted to restore power to datacenter control system (220 of Figure 4). Local station conditions or operational directives may cause flexible datacenter (200 of Figure 2) to ramp-up, reduce power consumption, change power factor, or ramp-down.

[0073] Advantages of one or more embodiments of the present invention may include one or more of the following:

[0074] In one or more embodiments of the present invention, a method and system for dynamic power delivery to a flexible datacenter using unutilized energy sources provides a green solution to two prominent problems: the exponential increase in power required for growing blockchain operations and the unutilized and typically wasted energy generated from renewable energy sources.

[0075] In one or more embodiments of the present invention, a method and system for dynamic power delivery to a flexible datacenter using unutilized energy sources allows for the rapid deployment of mobile datacenters to local stations. The mobile datacenters may be deployed on site, near the source of power generation, and receive unutilized behind-the-meter power when it is available.

[0076] In one or more embodiments of the present invention, a method and system for dynamic power delivery to a flexible datacenter using unutilized energy sources allows for the power delivery to the datacenter to be modulated based on conditions or an operational directive received from the local station or the grid operator.

[0077] In one or more embodiments of the present invention, a method and system for dynamic power delivery to a flexible datacenter using unutilized energy sources may dynamically adjust power consumption by ramping-up, ramping-down, or adjusting the power consumption of one or more computing systems within the flexible datacenter.

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[0078] In one or more embodiments of the present invention, a method and system for dynamic power delivery to a flexible datacenter using unutilized energy sources may be powered by unutilized behind-the-meter power that is free from transmission and distribution costs. As such, the flexible datacenter may perform computational operations, such as hashing function operations, with little to no energy cost.

[0079] In one or more embodiments of the present invention, a method and system for dynamic power delivery to a flexible datacenter using unutilized energy sources provides a number of benefits to the hosting local station. The local station may use the flexible datacenter to adjust a load, provide a power factor correction, to offload power, or operate in a manner that invokes a production tax credit.

[0080] While the present invention has been described with respect to the above-noted embodiments, those skilled in the art, having the benefit of this disclosure, will recognize that other embodiments may be devised that are within the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the appended claims.

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CLAIMS

What is claimed is:

1. A flexible datacenter comprising:
 - a mobile container;
 - a behind-the-meter power input system;
 - a power distribution system;
 - a datacenter control system;
 - a plurality of computing systems; and
 - a climate control system,wherein the datacenter control system modulates power delivery to the plurality of computing systems based on unutilized behind-the-meter power availability or an operational directive.
2. The flexible datacenter of claim 1, further comprising:
 - a remote master control system.
3. The flexible datacenter of claim 1, wherein the behind-the-meter power input system comprises an input configured to receive three-phase behind-the-meter AC voltage and a supervisory AC-to-AC step-down transformer configured to step down the three-phase behind-the-meter AC voltage to a single-phase supervisory nominal AC voltage or an input configured to receive single-phase supervisory nominal AC voltage from a local station or metered source.
4. The flexible datacenter of claim 3, wherein the behind-the-meter power input system provides the single-phase supervisory nominal AC voltage to the datacenter control system.
5. The flexible datacenter of claim 1, wherein the behind-the-meter power input system comprises an input configured to receive three-phase behind-the-meter AC voltage and an operational AC-to-AC step-down transformer configured to controllably step down the three-phase behind-the-meter AC voltage to three-phase nominal AC voltage.

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6. The flexible datacenter of claim 5, wherein the datacenter control system controllably enables or disables generation of the three-phase nominal AC voltage by the operational AC-to-AC step-down transformer.
7. The flexible datacenter of claim 1, wherein the behind-the-meter power input system provides three-phases of the three-phase nominal AC voltage to the power distribution system.
8. The flexible datacenter of claim 7, wherein the power distribution system controllably provides a single phase of the three-phase nominal AC voltage to each computing system of the plurality of computing systems.
9. The flexible data center of claim 7, wherein the datacenter control system controllably selects which phase of the three-phase nominal AC voltage the power distribution system provides to each computing system of the plurality of computing systems.
10. The flexible datacenter of claim 7, wherein the datacenter control system modulates a power factor correction factor by controllably adjusting which phase of the three-phase nominal AC voltage each computing system of the plurality of computing systems receive.
11. The flexible datacenter of claim 5, wherein the three-phase behind-the-meter AC voltage comprises a three-phase wind-generated AC voltage output by one or more wind turbines prior to an AC-to-AC step-up transformer that steps up the three-phase wind-generated AC voltage to a three-phase grid AC voltage.
12. The flexible datacenter of claim 5, wherein the three-phase behind-the-meter AC voltage comprises a three-phase solar-generated AC voltage output by a DC-to-AC inverter that inputs solar-generated DC voltage from one or more solar panels and prior to an AC-to-AC step-up transformer that steps up the three-phase solar-generated AC voltage to a three-phase grid AC voltage.

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13. The flexible datacenter of claim 5, wherein the three-phase behind-the-meter AC voltage comprises a three-phase gas-generated AC voltage output by a generator that inputs combustible gas diverted from a flare or venting system.
14. The flexible datacenter of claim 5, wherein the three-phase behind-the-meter AC voltage is a three-phase metered AC voltage.
15. The flexible datacenter of claim 1, wherein unutilized behind-the-meter power availability comprises one or more of excess local power generation at a local station level, excess local power generation that a grid cannot receive, local power generation subject to economic curtailment, local power generation subject to reliability curtailment, local power generation subject to power factor correction, low local power generation, start up local power generation situations, transient local power generation situations, or testing local power generation situations where there is an economic advantage to using local behind-the-meter power generation to power the flexible datacenter.
16. The flexible datacenter of claim 1, wherein an operational directive comprises one or more of a local station directive, a remote master control directive, or a grid directive.
17. The flexible datacenter of claim 1, wherein an operational directive comprises one or more of a dispatchability directive or a forecast directive.
18. The flexible datacenter of claim 1, wherein an operational directive comprises a workload directive based on actual behind-the-meter power availability or projected behind-the-meter power availability.
19. The flexible datacenter of claim 2, wherein the remote master control system dynamically adjusts power delivery to the flexible datacenter based on a remote master control directive.
20. The flexible datacenter of claim 1, wherein the climate control system comprises a computer room air conditioner system, a computer room air handler system, an evaporative cooling system, a refrigerant cooling system, an immersive cooling system,

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or any other suitable heat extraction system configured to operate the plurality of computing systems within their operational temperature range.

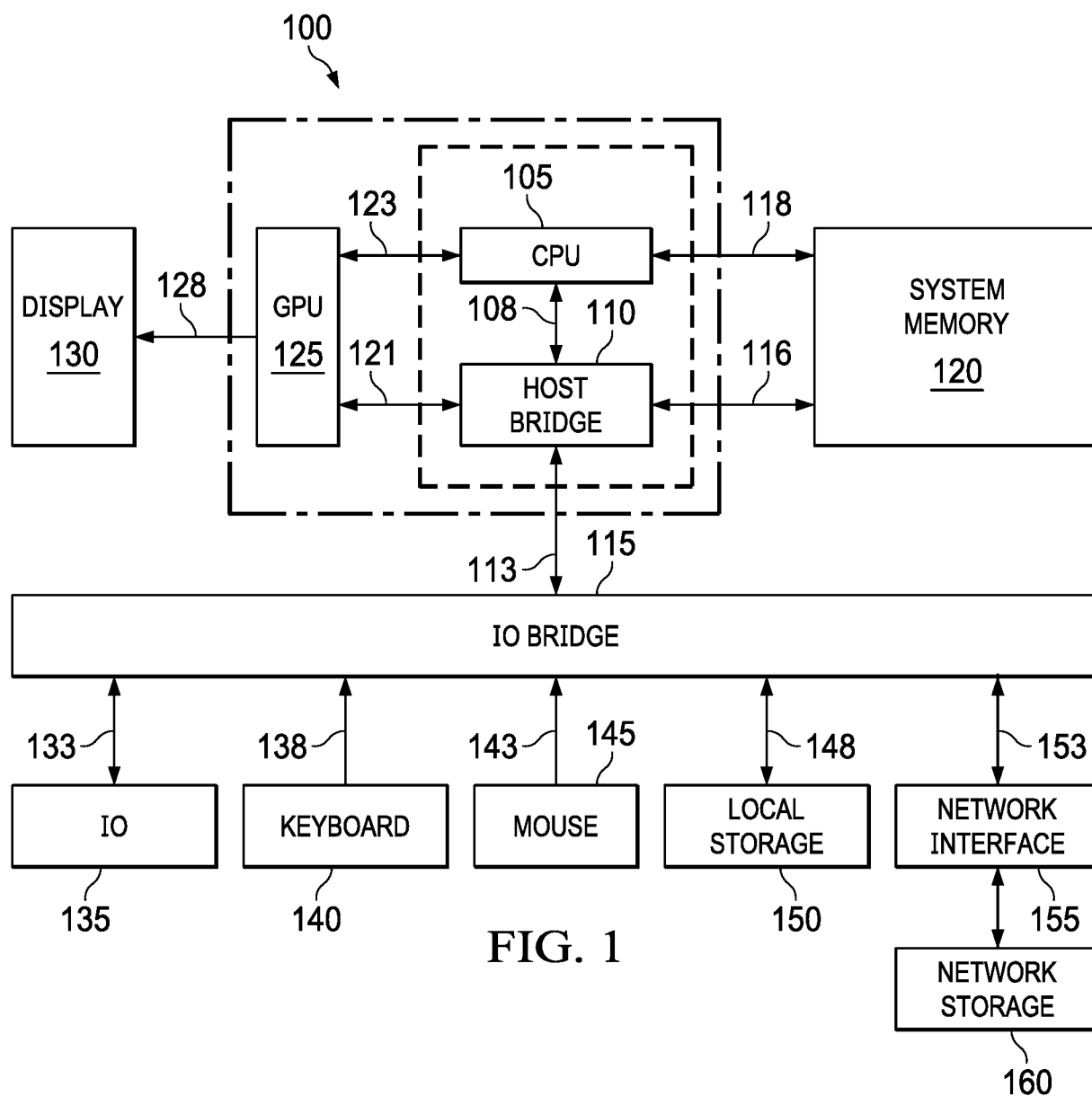
21. The flexible datacenter of claim 1, wherein the mobile container comprises a storage container configured for placement on a ground surface.
22. The flexible datacenter of claim 1, wherein the mobile container comprises a storage trailer on wheels.
23. The flexible datacenter of claim 5, further comprising a battery system configured to convert the three-phase nominal AC voltage to DC nominal voltage and store power in a plurality of storage cells.
24. The flexible datacenter of claim 23, wherein the DC nominal voltage from the plurality of storage cells are converted via a DC-to-AC inverter to three-phase nominal AC voltage for flexible datacenter use.
25. A method of dynamic power delivery to a flexible datacenter using unutilized behind-the-meter power comprising:
 - monitoring unutilized behind-the-meter power availability;
 - determining when a datacenter ramp-up condition is met;
 - enabling behind-the-meter power delivery to one or more computing systems when the datacenter ramp-up condition is met; and
 - directing the one or more computing systems to perform predetermined computational operations.
26. The method of claim 25, further comprising;
 - determining when a datacenter ramp-down condition is met; and
 - disabling power delivery to one or more computing systems when the datacenter ramp-down condition is met.
27. The method of claim 25, further comprising:
 - receiving an operational directive to go offline; and
 - disabling power delivery to the one or more computing systems.

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28. The method of claim 25, further comprising:
receiving an operational directive to reduce power consumption, and
dynamically reducing power delivery to a subset of the one or more computing systems.
29. The method of claim 25, further comprising:
receiving an operational directive to reduce power consumption; and
dynamically reducing power consumption of the one or more computing systems.
30. The method of claim 25, further comprising:
receiving an operational directive to provide power factor correction; and
dynamically adjusting power delivery to a subset of the one or more computing systems to achieve a desired power factor correction factor.
31. The method of claim 25, wherein unutilized behind-the-meter power availability comprises one or more of excess local power generation at a local station level, excess local power generation that a grid cannot receive, local power generation subject to economic curtailment, local power generation subject to reliability curtailment, local power generation subject to power factor correction, low local power generation, start up local power generation situations, transient local power generation situations, or testing local power generation situations where there is an economic advantage to using local behind-the-meter power generation.
32. The method of claim 25, wherein the datacenter ramp-up condition is met if there is sufficient behind-the-meter power availability and there is no operational directive from a local station to go offline.
33. The method of claim 25, wherein the datacenter ramp-down condition is met if there is insufficient behind-the-meter power availability or there is an operational directive from a local station to go offline.
34. The method of claim 25, wherein the predetermined computational operations comprise execution of one or more hashing functions.

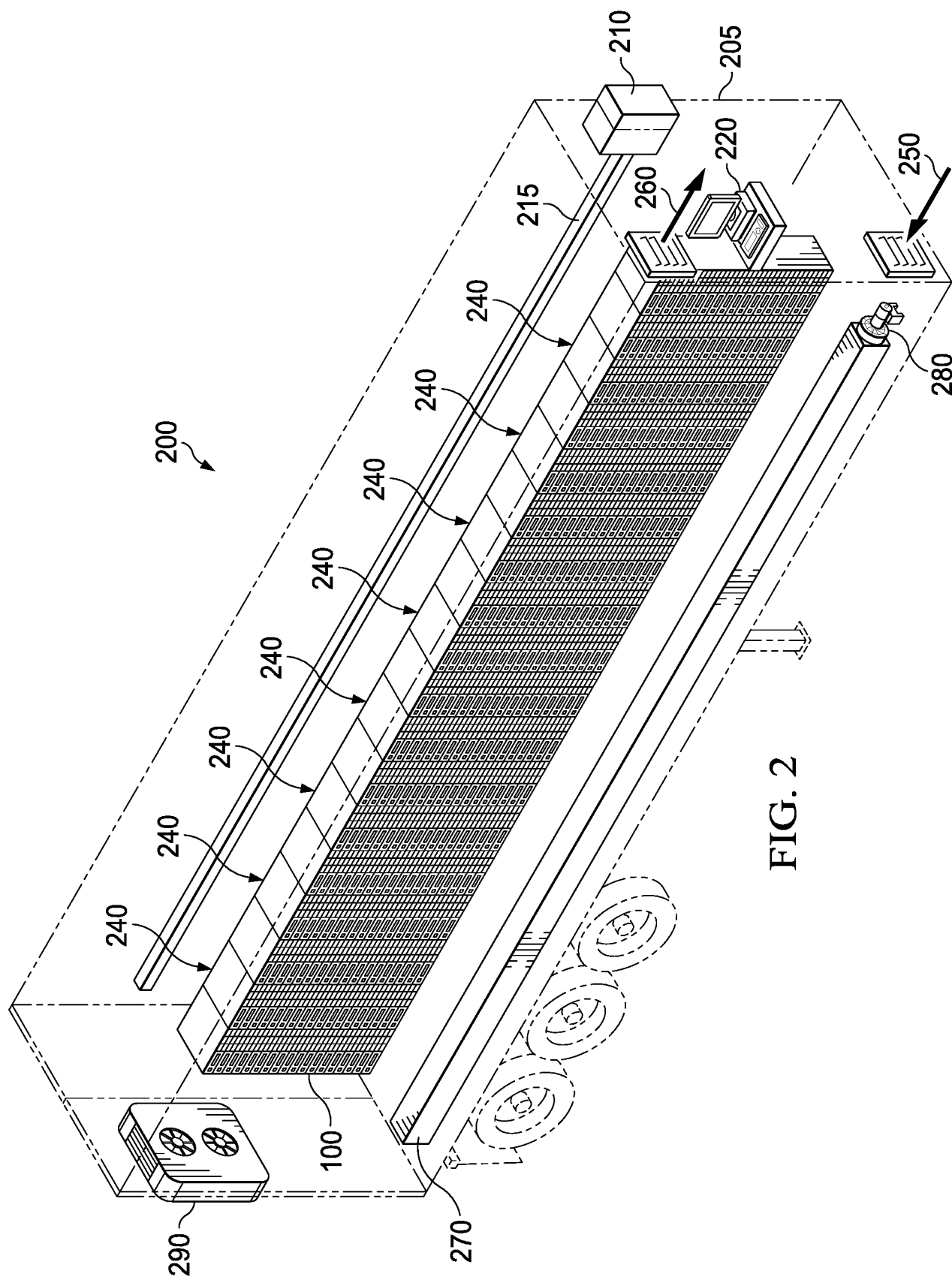
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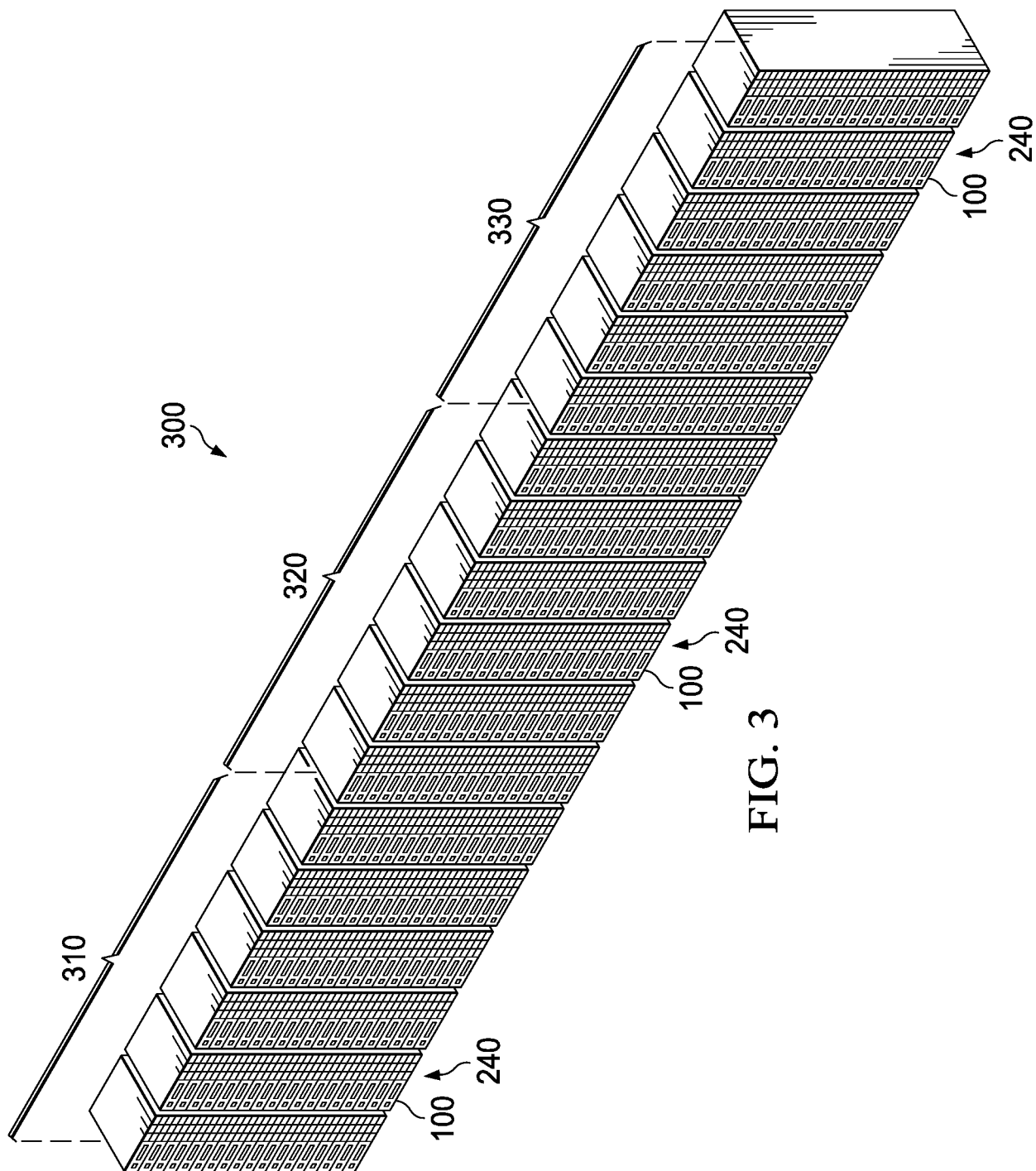
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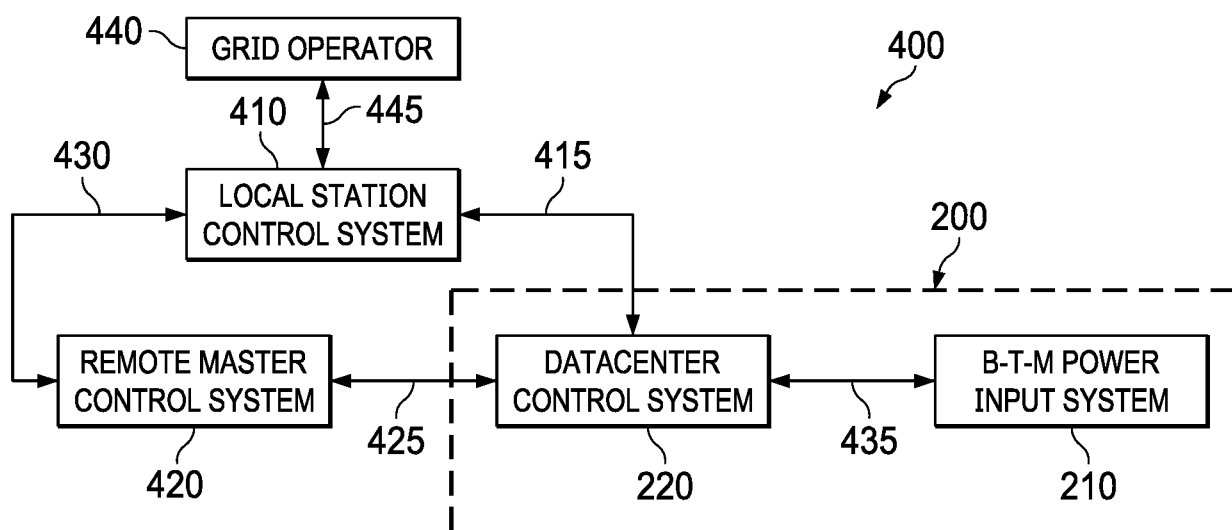


FIG. 4

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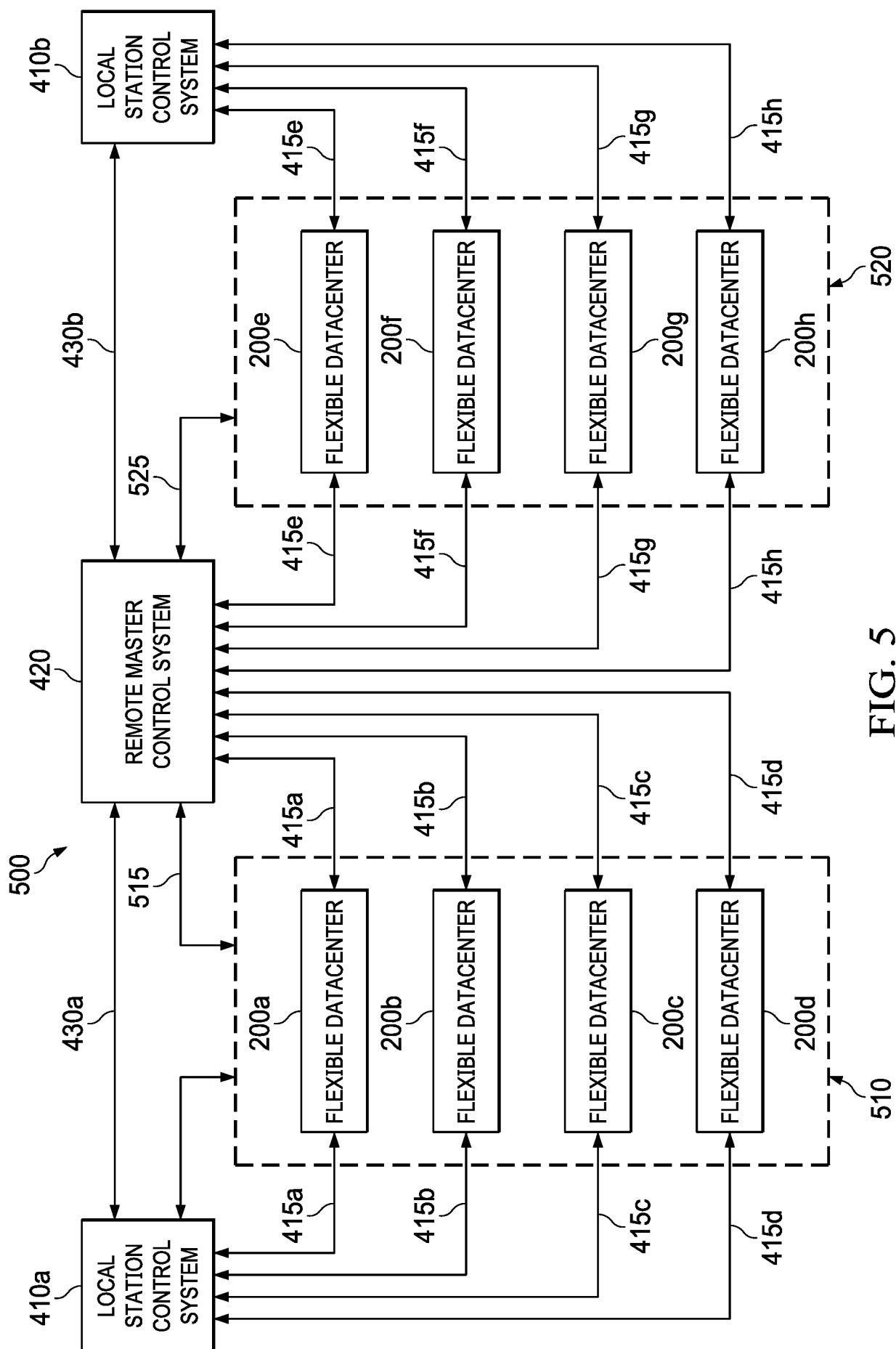


FIG. 5

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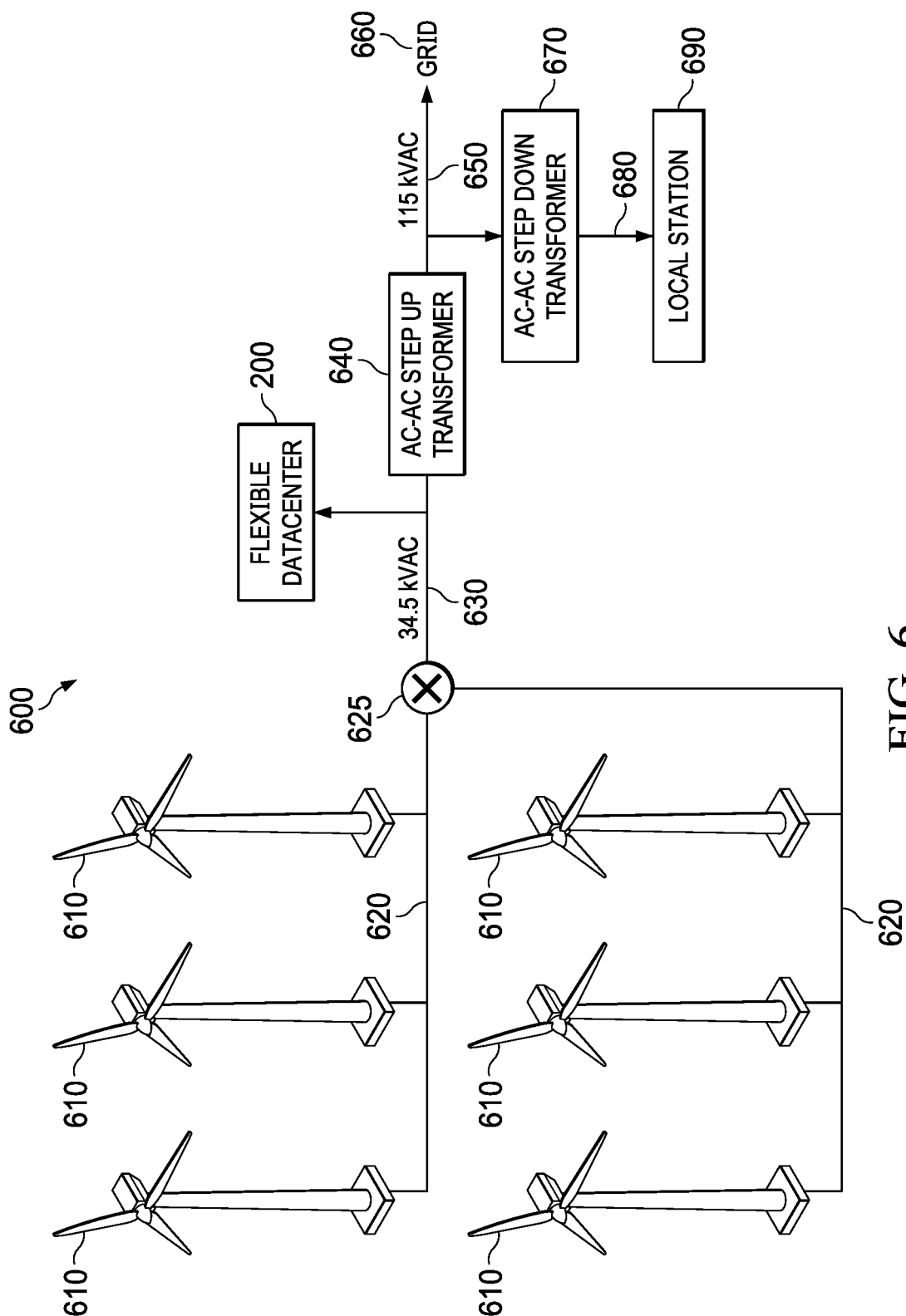
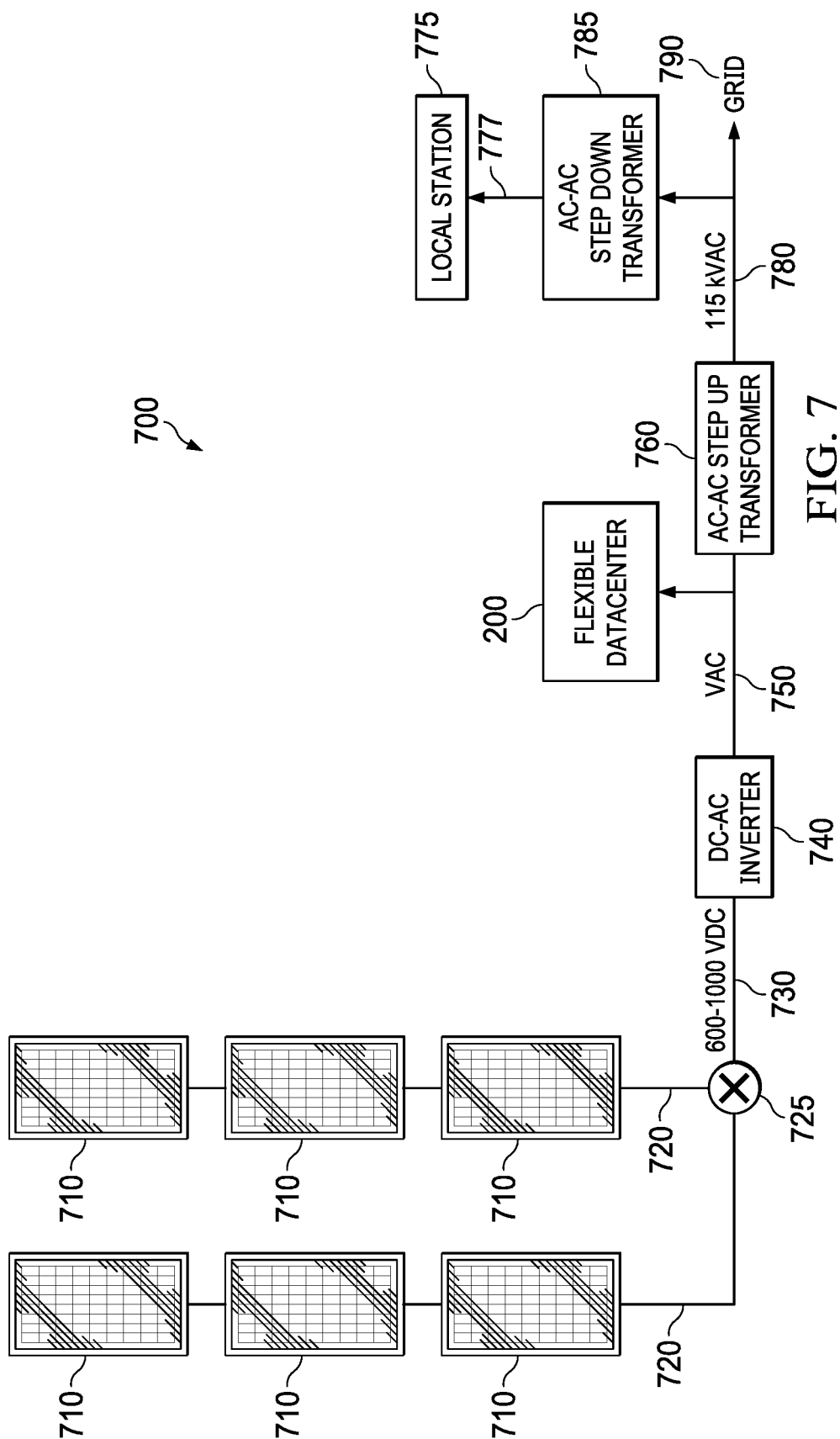


FIG. 6

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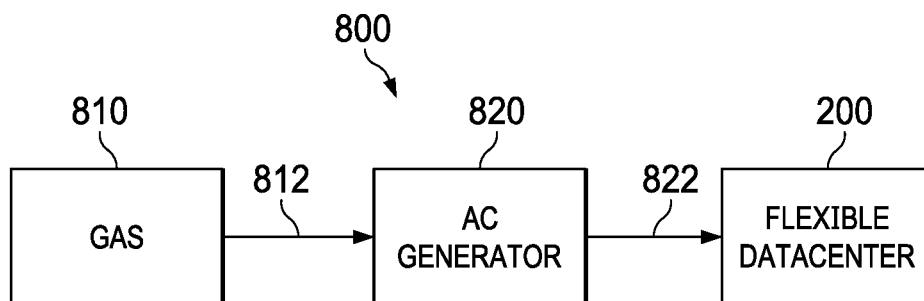


FIG. 8

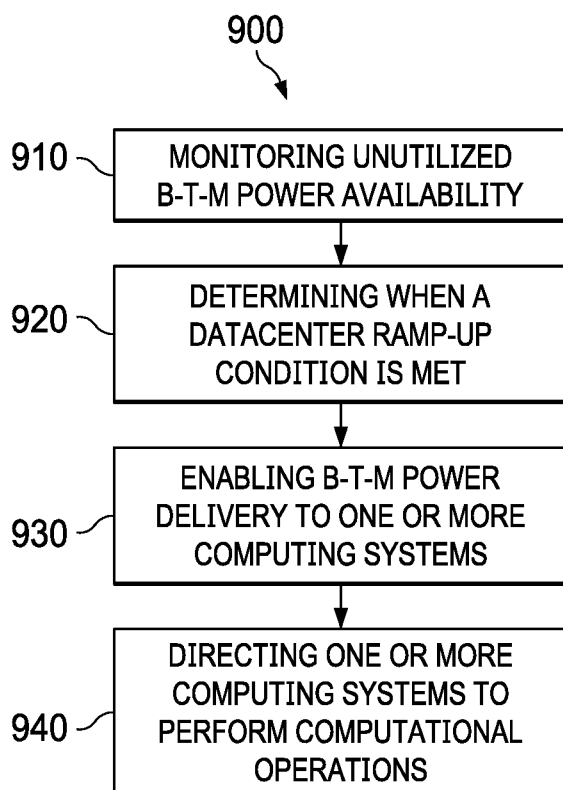


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2018/017950

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G06F 1/26; G06F 1/20; G06F 1/30; G06F 1/32 (2018.01)

CPC - G06F 1/26; H05K 7/1497; G06F 1/20; H05K 7/1485 (2018.05)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

USPC - 713/300; 361/679.46; 361/679.02 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---	US 2008/0094797 A1 (COGLITORE et al) 24 April 2008 (24.04.2008) entire document	1, 7, 15-18, 20-22 ---
Y		2-6, 8-14, 19, 23, 24
Y	US 2010/0211810 A1 (ZACHO) 19 August 2010 (19.08.2010) entire document	2, 19
Y	US 2008/0030078 A1 (WHITTED et al) 07 February 2008 (07.02.2008) entire document	3-6, 8-14, 23, 24
Y	US 2013/0063991 A1 (XIAO et al) 14 March 2013 (14.03.2013) entire document	12
Y	US 2015/0155712 A1 (INERTECH IP LLC) 04 June 2015 (04.06.2015) entire document	24
A	US 2010/0328849 A1 (EWING et al) 30 December 2010 (30.12.2010) entire document	1-24
A	US 2013/0306276 A1 (DUCHESNEAU) 21 November 2013 (21.11.2013) entire document	1-24
A	US 2012/0300524 A1 (FORNAGE et al) 29 November 2012 (29.11.2012) entire document	1-24

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

14 May 2018

Date of mailing of the international search report

31 MAY 2018

Name and mailing address of the ISA/US

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PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2018/017950

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
See extra sheet(s).

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-24

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2018/017950

Continued from Box No. III Observations where unity of invention is lacking

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claims 1-24, are drawn to a flexible datacenter comprising: a mobile container; and a behind-the-meter power input system.

Group II, claims 25-34, are drawn to a method of dynamic power delivery to a flexible datacenter using unutilized behind-the meter power comprising: monitoring unutilized behind-the-meter power availability; and determining when a datacenter ramp-up condition is met.

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical feature of the Group I invention: a flexible datacenter comprising: a mobile container; a behind-the-meter power input system; a power distribution system; a datacenter control system; and a climate control system, wherein the datacenter control system modulates power delivery to the plurality of computing systems as claimed therein is not present in the invention of Group II. The special technical feature of the Group II invention: monitoring unutilized behind-the-meter power availability; determining when a datacenter ramp-up condition is met; enabling behind-the-meter power delivery to one or more computing systems when the datacenter ramp-up condition is met; and directing the one or more computing systems to perform predetermined computational operations as claimed therein is not present in the invention of Group I.

Groups I and II lack unity of invention because even though the inventions of these groups require the technical feature of a flexible datacenter comprising one or more computing systems; and power delivery to the flexible datacenter using unutilized behind-the meter power availability, this technical feature is not a special technical feature as it does not make a contribution over the prior art.

Specifically, US 2010/0328849 to Ewing teaches a datacenter comprising one or more computing systems; and power delivery to the datacenter using power availability (if a server demands 500 watts and the PUE for the datacenter is 3.0, then the power from the utility grid needed to deliver 500 watts to the server is 1500 watts. The DCIE, in comparison, may provide a different aspect of this information, a DCIE value of 0.33 (equivalent to a PUE of 3.0) suggesting that the computing equipment consumes 33% of the power in the data center, para.0060). Further, US 2013/0306276 to Duchesneau teaches a flexible datacenter (supercomputing datacenter, Para. [0315. Maximum flexibility, para. 1500]); and using unutilized behind-the meter power availability (PERKS is hybrid energy system combining UPS with a peak-shaving system that directly captures excess or low-cost energy from a multiplicity of sources (when it is cheapest or most readily available) and stores it for later reuse, such as during peak periods, Para. [1456]. Note that excess energy is hereby "unutilized behind the meter power" as defined by applicant in Para [0041] of the specification of the present application).

Since none of the special technical features of the Group I or II inventions are found in more than one of the inventions, unity of invention is lacking.